water must have become fresh by diffusion very slowly to allow of the gradual adaptation of the crustaceans to the change of element. Possibly the occurrence at the bottom of salt springs like those of the adjacent shores of Michigan may have had something to do with the slowness of the change. At present the bottom water, judging from a specimen we obtained from a depth of fifty fathoms approximately, is entirely fresh.

I am informed by Professor Gill that the *Triglopsis Thompsonii* of Girard is a marine rather than a fresh-water form. This fish inhabits the depths of the lakes, having been found by Professor Baird in the stomach of *Lota maculosa*, taken in Lake Ontario, and recently by Dr. Hoy in those of trout caught off Racine.

Our *Mysis* is allied to certain arctic forms, which would lead us to refer its original entry into the lakes to the cold period of the quaternary epoch. While the marine species usually live near the surface of the water, this one appears to be confined to the bottom, a result of its seeking the colder and at a former period the more saline waters.

The investigation of the materials obtained by the dredging parties of the Academy is now in progress, and the results will be published in full with illustrations at an early period.

CLIMBING PLANTS.

BY PROF. W. J. BEAL.

THE following remarks upon this interesting subject, can scarcely be called a review, but more properly a summary given nearly in the words of the author.* It has been made

* On the Movements and Habits of Climbing Plants. By Charles Darwin, Esq., F.R.S., F.L.S., etc. [From the Journal of the Linnæan Society.] pp. 118. London, 1865.

quite full, as it is likely the original paper has been read by but few readers of the NATURALIST.

Climbing plants may be divided into those which spirally twine round a support; those which ascend by the movement of the foot-stalks or tips of their leaves; those which ascend by true tendrils; those which are furnished with hooks, and those which are furnished with rootlets. The last two exhibit no special movements and are of less interest than the first three.

Spirally Twining Plants.—I begin with a special case, one depending upon my own observation, similar to the one taken by Mr. Darwin. A thrifty hop-vine in my yard went up nine or ten feet to the top of a stake. Still aspiring it ran above the support, at the same time reaching off and swinging round and round following the course of the sun. When about two feet above the stake the tip of the vine circumscribed a circle two feet in diameter. While it grew longer the extent of the circle was about the same, as a part of the vine had become strong and remained nearly stationary. By observations made at different times in the day it was found to perform one revolution in from one to two hours, moving most rapidly in the warmest part of the warmest days. It is now four feet and two inches above any artificial support, and has just tipped over to the north-east in the direction of the prevailing wind. The revolving movement lasts as long as the plant continues to grow, but each separate joint or internode, as it grows old, ceases to move. In the case of the hop and most other twining plants, about three internodes at a time partake of the motion.

The *Hoya carnosa* (*Asclepiadaceæ*) revolves opposite to the sun in five or six hours, making a circle of over five feet in diameter. The tip traced thirty-two inches per hour. It was an interesting spectacle to watch the long shoot sweeping night and day this grand circle in search of some object round which to twine. Sometimes it described nar-

row ellipses. After performing thirty-seven revolutions the stem of a hop was found to be twisted three times round its own axis in the direction of the sun. To prove that the twisting of the stem does not cause the revolutions, as Hugo von Mohl supposed, *some* stems are not regularly twisted and *others* twist in an opposite direction to the revolving plant. In many twining plants the end of the shoot is hooked so as the more readily to hold fast to any object of support which may be caught. This support once found, the point of contact ceases to move, but the tip continues to twine above and around the support as a rope swung around a stick will coil in the direction of the swinging rope.

If a stick shortly after having been wound round be withdrawn, the shoot retains for a time its spiral form, then straightens itself and again begins to revolve. Mohl believed that plants twined because of a dull irritability of the stem, but experiments prove that this is not generally the case.

If the support of a twiner be not lofty it falls to the ground, and resting there the extremity rises again. Sometimes several flexible shoots twine together into a cable and thus support each other. Single thin shoots will fall and turn abruptly back and wind upwards on themselves. The majority of twiners move in a course opposed to that of the sun or the hands of a watch. Rarely plants of the same order twine in opposite directions, but no instance is known of two species of the same genus twining in opposite directions. Of seventeen plants of *Loasa aurantiaca*, eight revolved in opposition to the sun and ascended from left to right, five followed the sun and ascended from right to left, and four revolved and twined first in one direction, and then reversed their course. One of these four plants made seven spiral turns from right to left, and five turns from left to right. Climbers of the temperate zone will not generally twine around thick trees, while those of the tropics can. Unless this were the case those of the tropics could hardly

ever reach the light. In our temperate countries twiners which die down every year would gain nothing as they could not reach the summit in a single season. With most twining plants all the branches, however many there may be, go on revolving together; but, according to Mohl, the main stem of *Tamus elephantipes* does not twine—only the branches. On the other hand, with the asparagus, given in the table, the leading shoot alone, and not the branches, revolved and twined. Some produce shoots of two sorts, one of which twines; the others not. In others the uppermost shoots alone twine. One twines during the middle of the summer but not in autumn. Some grow erect in dry South Africa, their native country; but near Dublin, Ireland, they regularly twine.

Leaf Climbers.—The stems of several species of *Clematis* are twiners like the hop. But in addition to this mode of holding fast, the petioles are sensitive to the touch, slowly bend into the form of hooks, and if successful in catching a stick they clasp it firmly and soon become greatly enlarged and strengthened by an extra growth of woody fibre. If they come in contact with no object they retain this position for a considerable time, and then bending upwards they reassume their original upturned position, which is retained ever afterwards. In *Clematis calycina* the clasped petiole becomes nearly twice as thick as the leaf-stalk which has clasped nothing. The petiole of the unclasped leaf is flexible, and can be easily snapped, whereas the clasped footstalk acquires an extraordinary toughness and rigidity so that considerable force is required to pull it into pieces. The meaning of these changes is plain, namely, that the petioles may firmly and durably support the stem. In some species of *Clematis* furnished with compound leaves the main petiole alone is sensitive, while some have two or three sub-petioles, also sensitive; still others have the entire number, as many as seven, sensitive. Some petioles are extremely sensitive to very light weights, as one-eighth

of a grain. They will clasp thin withered blades of grass, the soft young leaves of a maple, or the lateral flower peduncles of the quaking grass *Briza;* the latter are only about as thick as a hair from a man's beard, but they were completely surrounded and clasped.

The first petiole of *Tropæolum tricolorum* var. *grandiflorum* bear no laminæ or blades, and are very sensitive to touch, sometimes bending into a complete ring in six minutes. The next filaments above have their tips slightly enlarged, and those still farther up the stem still more enlarged; so we find all grades, from tendrils to leaves with large blades. All of these petioles are sensitive; those without blades acting in every way like genuine tendrils; the latter are short lived, however, dropping off as soon as the petioles of the true leaves have clasped the support above. The most remarkable fact, and which I have observed in no other species of the genus, is that the filaments and petioles of the young leaves, if they catch no object, after standing in their original position for some days, spontaneously and slowly move, oscillating a little from side to side towards the stem of the plant. Hence all the petioles and filaments, though arising on different sides of the axis, ultimately bend towards and clasp either their own stem or the supporting stick. The petioles and filaments often become, after a time, in some degree contracted, presenting features much like true tendrils.

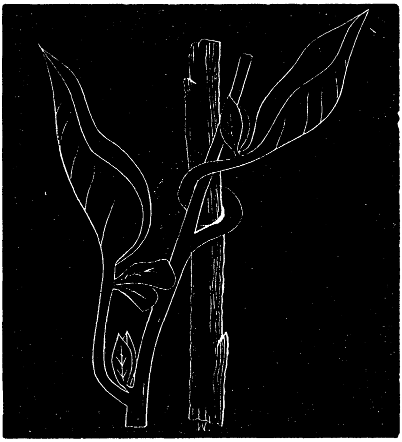
Maurandia semperflorens (*Scrophulariaceæ*) has flower peduncles which are sensitive like tendrils, and exhibit revolving powers. These spontaneous movements seem to be of no service to the plant as they lose the power when the flower is old enough to open. The leaf-stalks and internodes of this plant do not twine.

Lophospermum scandens var. *purpureum* when young has sensitive internodes. When a petiole clasps a stick it draws the base of the internode against it; and then the internode itself bends towards the stick, which is thus

caught between the stem and the petiole as by a pair of pincers. The internode straightens itself again, excepting the part in contact with the stick.

With *Solanum jasminoides* (Fig. 88) as in no other leaf-climber examined, a leaf grown to its full size was capable of clasping a stick; but the movement was extremely slow, requiring several weeks. On comparing a thin transverse slice of this petiole with one from the next or older leaf beneath, which had not clasped anything, its diameter was found to be fully doubled, and its structure greatly changed. In the section of the petiole which had during several weeks clasped a stick, the two upper ridges have become much less prominent, and the two groups of woody vessels beneath them much increased in diameter. The semilunar band is converted into a complete ring of very hard, white, woody tissue, with lines radiating from the centre. The three groups of vessels, which, though closely approximate, were before distinct, are now completely blended together. This clasped petiole had actually become thicker than the stem close beneath; due chiefly to the greater thickness of the ring of wood.

Fig. 88.



Solanum jasminoides.

Plants belonging to eight families are known to have clasping petioles, and plants belonging to four families climb by the tips of their leaves. With rare exceptions the petioles are sensitive only whilst young; they are sensitive on all sides, but in different degrees in different plants.

Tendril-bearing Plants. — By tendrils are meant filamentary organs, sensitive to contact and used exclusively

for climbing. They are formed by the modification of leaves with their petioles, of flower-peduncles, perhaps also of branches and stipules. The species of tendril bearers described belong to ten natural families. Species of *Bignonia* and some others taken together, afford connecting links between twiners, leaf-climbers, tendril-bearers, and root climbers. Some little time after the stem of *Bignonia Tweedyana* has twined round an upright stick, and is securely fastened to it by the clasping petioles and tendrils, it emits at the base of its leaves aërial roots which curve partly round and adhere to the stick; so that this one species of *Bignonia* combines four different methods of climbing, generally characteristic of distinct plants, namely, twining, leaf-climbing, tendril-climbing, and root-climbing.

The movements of *Bignonia venusta* are quite complicated. Not only the tendrils but the petioles bearing them revolve; these petioles, however, are not in the least sensitive. Thus the young internodes, the petioles, and the tendrils, all at the same time, go on revolving together, but at different rates. Moreover the movements of the opposite petioles and tendrils are quite independent of each other. One other curious point remains to be mentioned. In a few days after the toes have closely clasped a stick, their blunt extremities become, though not invariably, developed into irregular disk-like balls, which have the singular power of adhering firmly to the wood.

The simple undivided tendril of *Bignonia speciosa* ends in an almost straight, sharp, uncolored point. The whole terminal part exhibits an odd habit, which in an animal would be called an instinct; for it continually searches for any little dark hole into which to insert itself. The tendrils slowly travel over the surface of the wood, and when the apex came to a hole or a fissure it inserted itself, often bending at right angles to the basal part. The same tendril would frequently withdraw from one hole and insert its point into a second one. Mr. Darwin says: "Improbable as this view may be

I am led to suspect that this habit in the tendril of inserting its tip into dark holes and crevices has been inherited by the plant after having lost the power of forming adhesive disks."

A plant of *Bignonia capreolata* was several times shifted in position in a box where one side only was exposed to the light; in two days all six tendrils pointed with unerring truth to the darkest corner of the box, though to do this each had to bend in a different manner. Six tattered flags could not have pointed more truly from the wind than did these branched tendrils from the stream of light which entered the box. When a tendril does not succeed in clasping a support it bends downwards and then towards its own stem, which it seizes, together with the supporting stick, if there be one. If the tendril seizes nothing it does not contract, spirally, but soon withers away and drops off. A bunch of wool was placed in the way of the tendrils; they caught one or two fibres and then the tips began to swell into irregular balls above the one-twentieth of an inch in diameter. The surfaces of these balls secrete some viscid resinous matter, to which the fibres of the wool adhere, so that after a time fifty or sixty fibres are all deeply imbedded in one ball of tendril. These tendrils quite fail to attach themselves to a brick wall. These plants are especially adapted to climb trees clothed with lichens and mosses which abound on the trees in the native country of the *Bignonia*.

Cobœa scandens (*Polemoniaceæ*) is an admirable climber. The terminal portion of the petiole which forms the tendril is sometimes eleven inches long. The tendril performs one revolution against the sun in an hour and a quarter. The base of the petiole and the internodes do not move at all.

A large majority of the tendrils of *Corydalis claviculata* still bear leaflets, though excessively reduced in size. We here behold a plant in an actual state of transition from a leaf-climber to a tendril-bearer. Whilst the plant is young, only the outer leaves, but when full-grown all the leaves, have their extremities more or less perfectly converted into tendrils.

Echinocystis lobata. A thin, smooth, cylindrical, stick was placed so far from a tendril that its extremity could only curl half or three-quarters round the stick. It was always found in the course of a few hours afterwards that the tip had managed to curl twice or even thrice quite round the stick. Measurements showed that this was not due to the growth of the tendril. Whilst the tendril was slowly and quite insensibly crawling onwards it was observed that the whole surface was not in close contact with the stick. The onward movement is supposed to be slightly vermicular, or that the tip alternately straightens itself a little and then again curls inwards, thus dragging itself onwards by an insensibly slow, alternate movement, which may be compared to that of a strong man suspended by the ends of his fingers to a horizontal pole, who works his fingers onwards until he can grasp the pole with the palm of his hand. Experiments upon this interesting plant were made and the results published by Dr. Asa Gray, in 1858. This led Mr. Darwin to more extended observations upon many other climbing plants. He is only one of a large number of persons who are indebted for valuable hints from the sagacious botanist of Cambridge, Mass.

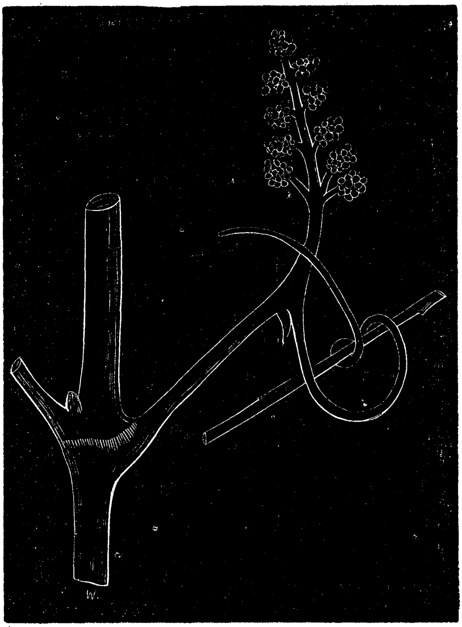
Hanburya Mexicana. In a few days after the tips of the tendrils have grasped an object the inferior surface swells and becomes developed into a cellular layer, which adapts itself closely to the wood, and firmly adheres to it. This is not the extreme tip of the tendril but a trifle back of it. This layer apparently secretes some resinous cement, as it is not loosened by water or alcohol, but is freed by the action of ether and turpentine.

Tendrils of plants belonging to *Vitaceæ*, *Sapindaceæ*, *Passifloraceæ*, and perhaps others, are modified flower peduncles, but their homological nature makes no difference in their action. Figure 89 shows part of the tendril of a grapevine bearing flowers. From this state we can trace every stage till we come to a full-sized common tendril, bearing on

the branch which corresponds with the sub-peduncle one single flower-bud!

Ampelopsis quinquefolia (Fig. 90, tendril, with the young leaf. Fig. 91, tendril, several weeks after its attachment to a wall, with the branches thickened and spirally contracted, and with the extremities developed into disks. The unattached branches have withered and dropped off.) climbs by tendrils like the grape-vine, but in addition has a way of holding fast to plain surfaces by means of little disks or cushions. These disks are apparently never developed without a contact with some object. A tendril which has not become attached to any body does not contract spirally; and in course of a week or two shrinks into the finest thread, withers and drops off. An attached tendril, on the other hand, contracts spirally, and thus becomes highly elastic; so that when the main foot-stalk is pulled, the strain is equally distributed to all the attached disks. During the following winter it ceases to live but remains firmly attached to the stem and to the surface of attachment. The gain in strength and durability in a tendril after its attachment is something wonderful. They adhere still strong after an exposure to the weather for fourteen or fifteen years. One single lateral branchlet of a tendril, estimated to be at least

Fig. 89.

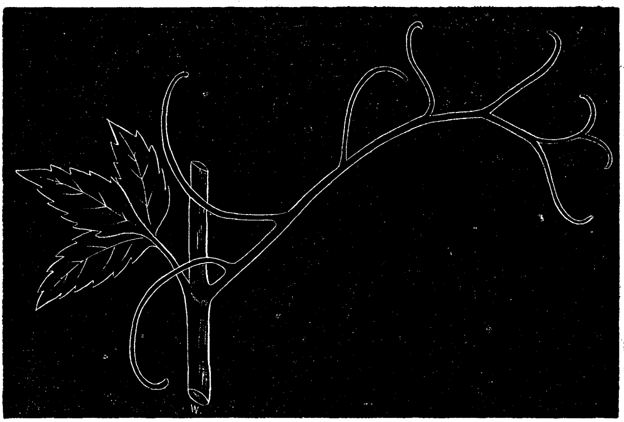


Grape-vine.

ten years old, was still elastic and supported a weight of exactly two pounds. This tendril had five disk-bearing branches of equal thickness and of apparently equal strength, so that this one tendril, after having been exposed during ten years to the weather, would have resisted a strain of ten pounds!

Spiral Contractions.—Tendrils of many kinds of plants if they catch nothing, contract after an interval of several

Fig. 90.



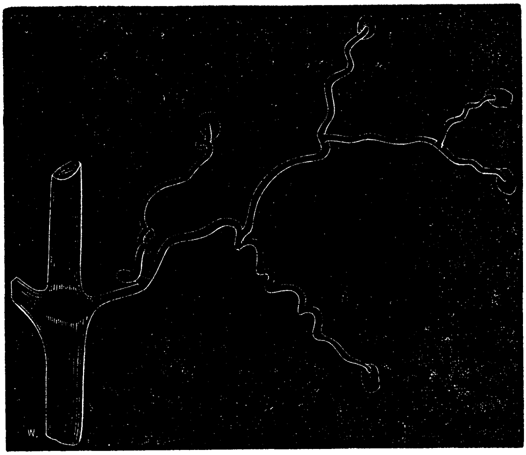
Woodbine.

days or weeks into a close spire. A few contract into a helix.

The spiral contraction which ensues after a tendril has caught a support is of high service to all tendril-bearing plants; hence its almost universal occurrence with plants of widely different orders. When caught the spiral contraction drags up the shoot. Thus there is no waste of growth, and the stretched stem ascends by the shortest course. A far more important service rendered by the spiral contraction is that the tendrils are thus made highly elastic. The strain, as in *Ampelopsis*, is thus equally distributed to the several attached branches of a branched tendril. It is this elasticity which saves both branched and simple tendrils from being torn away during stormy weather. In one case observed

the *Bryony* (Fig. 92) safely rode out the gale, like a ship with two anchors down, and with a long range of cable ahead to serve as a spring as she surges to the storm. When an uncaught tendril contracts spirally the spire always runs in the same direction from tip to base. A tendril, on the other hand, which has caught a support by its extremity, invariably becomes twisted in one part in one direction, and in another part in the opposite direction; the oppositely turned spires being separated by short, straight portions. Sometimes the spires of a tendril alternately turn as many as five times in opposite directions, with straight portions between them; even seven or eight have been seen by M. Léon. Whether few spires, or many, there are as many in one direction as in the other. To give an illustration; when a haberdasher winds up ribbon for a customer he does not wind it into a single coil; for, if he did, the ribbon would twist itself as many times as there were coils; but he winds it into a figure of eight on his thumb and little finger, so that he alternately takes turns in opposite directions, and thus the ribbon is not twisted. So it is with tendrils, with this sole difference, that they take several consecutive turns in one direction, and then the same number in an opposite direction; but in both cases the self-twisting is equally avoided. *Passiflora gracilis* has the most sensitive tendrils which were seen; a bit of

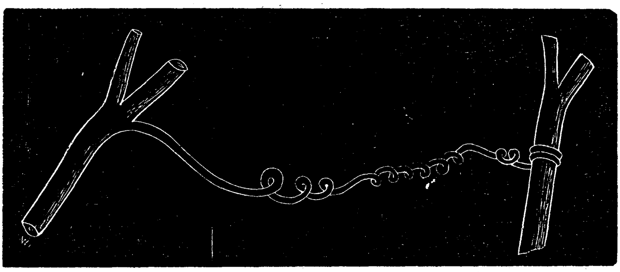
Fig. 91.



Woodbine.

platina wire, one-fiftieth of a grain in weight, gently placed on the concave point, caused two tendrils to become hooked. After a touch the tendril began to move in twenty-five seconds. Dr. Asa Gray saw tendrils of *Sicyos* move in thirty seconds. Other tendrils move in a few minutes; in the *Dicentra* in half an hour; in the *Smilax* in an hour and a quarter; and in the *Ampelopsis* still more slowly. Tendrils move to the touch of almost any substance, drops of water excepted. Adjoining tendrils rarely catch each other. Some tendrils have their revolving motion accelerated and retarded in moving to and from the light; others are indifferent to its action. America which so abounds with arboreal animals

Fig. 92.



Bryony.

abounds with climbing plants; and, of the tendril-bearing plants examined the most admirably constructed come from this grand continent, namely, the several species of *Bignonia*, *Eccremocarpus*, *Cobœa*, and *Ampelopsis*.

Root Climbers.—*Ficus repens* climbs up walls just like ivy; when the young rootlets were made to press lightly on slips of glass they emitted, after about a week's interval, minute drops of clear fluid, slightly viscid. One small drop the size of half a pin's head, was mixed with grains of sand. The slip of glass was left exposed in a drawer during hot and dry weather. The mass remained fluid during one hundred and twenty-eight days; how much longer was not observed. The rootlets seem to first secrete a slightly viscid

fluid and then absorb the watery plants, and ultimately leave a cement.

Plants become climbers, in order, it may be presumed, to reach the light, and to expose a large surface of leaves to its action and to that of the free air. This is effected by climbers with wonderfully little expenditure of organized matter, in comparison with trees, which have to support a load of heavy branches by a massive trunk. Because these climbing plants graduate into each other they have "become" climbers by gradual changes. This looks too much like the old fanciful theory that has again and again appeared, namely, the giraffe acquired his long neck by a constant desire for high twigs, and an effort to reach them; the elephant his long trunk by a similar desire and effort to reach the grass at his feet. We cannot see how homology indicates descent. We do not believe because the various modes of inflorescence run into each other (*homologous*) that they have all been derived from one common form. Mr. Darwin believes that leaf-climbers were primordially twiners, and tendril-bearers were primordially leaf-climbers; and thinks he understands how the change has been brought about; yet he says "if we inquire how the petiole of a leaf, or the peduncle of a flower, or a branch, first becomes sensitive and acquires the power of bending towards the touched side, we get no certain answer." We are again silenced if we inquire how the stems, petioles, tendrils, and flower peduncles first acquired their power of spontaneously revolving. Below we give a good sample of Darwinism.

"If these views be correct *Lathyrus nissolia* must be descended from a primordial spirally-twining plant; that this became a leaf-climber; that first, part of the leaf, and then the whole leaf became converted into a tendril, with the stipules by compensation greatly increased in size; that this tendril lost its branches and became simple, then lost its revolving-power (in which state it would resemble the tendril of the existing *L. aphaca*), and afterwards losing its pre-

hensile power and becoming foliacious, would no longer be called a tendril. In this last stage (that of the existing *L. nissolia*), the former tendril would reassume its original function of a leaf, and its lately largely developed stipules being no longer wanted would decrease in size." He believes that the capacity of acquiring the revolving power on which most climbers depend is inherent, though undeveloped, in almost every plant in the vegetable kingdom. Notwithstanding his peculiar views, which are so enticing to many, we must acknowledge that he is a shrewd and accurate observer, and that in this paper, as in many others, he has patiently collected a vast amount of valuable information upon a great variety of subjects.

REVIEWS.

Natural Selection.* — Mr. Wallace has here brought together, in a compact little book, all those essays which have laid the foundation of his great reputation as the author, in common with Mr. Darwin, of the theory of Natural Selection. The modesty of the author, and that admirable judicial coolness of mind which he shares in common with Darwin, is a most persuasive introduction, and produces a favorable disposition in the mind of the reader, which the candid style of treating the different subjects greatly strengthens. In fact we have rarely read a work which has given us so much pleasure and information, and we recommend it to all those who desire to get the principles of Darwinism but have not the patience to spend a longer time over Darwin's work.

The first chapter shows that geological changes determine the variations which take place in the geographical distribution of animals and plants; that closely allied animals are closely associated geographically and geologically, so that "every species has come into existence coincident both in time and space with a preëxisting closely allied species." The author then proceeds to show how variations in animals occur, and incidentally introduces an ingenious and remarkable explanation of the reversions of domesticated types when returned to a feral condition. A domesticated type, when allowed to become wild again, generally speak-

* Contributions to the Theory of Natural Selection. A Series of Essays by Alfred Russell Wallace, McMillan & Co., London and New York, 8vo, p. 384.